PATENT COOPERATION TREATY

PCT

INTERNATIONAL PRELIMINARY EXAMINATION REPORT

(PCT Article 36 and Rule 70)

Applicant's or agent's file reference P16416-ATO	FOR FURTHER ACTION	See Notification of Transmittal of International Preliminary Examination Report (Form PCT/IPEA/416)
International application No. PCT/EP 03/04526	International filing date *(day/month/year)* 30.04.2003	Priority date *(day/month/year)* 30.04.2003
International Patent Classification (IPC) or both national classification and IPC H03F1/32		
Applicant TELEFONAKTIEBOLAGET LM ERICSSON (PUBL) ET AL.		

1. This international preliminary examination report has been prepared by this International Preliminary Examining Authority and is transmitted to the applicant according to Article 36.

2. This REPORT consists of a total of 5 sheets, including this cover sheet.

   ☒ This report is also accompanied by ANNEXES, i.e. sheets of the description, claims and/or drawings which have been amended and are the basis for this report and/or sheets containing rectifications made before this Authority (see Rule 70.16 and Section 607 of the Administrative Instructions under the PCT).

   These annexes consist of a total of 5 sheets.

3. This report contains indications relating to the following items:

   - I ☒ Basis of the opinion
   - II ☐ Priority
   - III ☐ Non-establishment of opinion with regard to novelty, inventive step and industrial applicability
   - IV ☐ Lack of unity of invention
   - V ☒ Reasoned statement under Rule 66.2(a)(ii) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement
   - VI ☐ Certain documents cited
   - VII ☐ Certain defects in the international application
   - VIII ☐ Certain observations on the international application

Date of submission of the demand	Date of completion of this report
10.11.2004	05.07.2005
Name and mailing address of the international preliminary examining authority: European Patent Office - P.B. 5818 Patentlaan 2 NL-2280 HV Rijswijk - Pays Bas Tel. +31 70 340 - 2040 Tx: 31 651 epo nl Fax: +31 70 340 - 3016	Authorized Officer Fedi, G Telephone No. +31 70 340-2280

I. Basis of the report

1. With regard to the **elements** of the international application *(Replacement sheets which have been furnished to the receiving Office in response to an invitation under Article 14 are referred to in this report as "originally filed" and are not annexed to this report since they do not contain amendments (Rules 70.16 and 70.17))*:

Description, Pages

1, 2, 4-11	as originally filed
3, 3a	received on 18.06.2005 with letter of 15.06.2005

Claims, Numbers

1-11	received on 18.06.2005 with letter of 15.06.2005

Drawings, Sheets

1/2-2/2	as originally filed

2. With regard to the **language**, all the elements marked above were available or furnished to this Authority in the language in which the international application was filed, unless otherwise indicated under this item.

   These elements were available or furnished to this Authority in the following language: , which is:

   ☐ the language of a translation furnished for the purposes of the international search (under Rule 23.1(b)).

   ☐ the language of publication of the international application (under Rule 48.3(b)).

   ☐ the language of a translation furnished for the purposes of international preliminary examination (under Rule 55.2 and/or 55.3).

3. With regard to any **nucleotide and/or amino acid sequence** disclosed in the international application, the international preliminary examination was carried out on the basis of the sequence listing:

   ☐ contained in the international application in written form.

   ☐ filed together with the international application in computer readable form.

   ☐ furnished subsequently to this Authority in written form.

   ☐ furnished subsequently to this Authority in computer readable form.

   ☐ The statement that the subsequently furnished written sequence listing does not go beyond the disclosure in the international application as filed has been furnished.

   ☐ The statement that the information recorded in computer readable form is identical to the written sequence listing has been furnished.

4. The amendments have resulted in the cancellation of:

   ☐ the description, pages:

   ☐ the claims, Nos.:

   ☐ the drawings, sheets:

5. ☐ This report has been established as if (some of) the amendments had not been made, since they have been considered to go beyond the disclosure as filed (Rule 70.2(c)).

   (Any replacement sheet containing such amendments must be referred to under item 1 and annexed to this report.)

6. Additional observations, if necessary:

V. Reasoned statement under Article 35(2) with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. Statement

Novelty (N)	Yes:	Claims	1-11
	No:	Claims	
Inventive step (IS)	Yes:	Claims	1-11
	No:	Claims	
Industrial applicability (IA)	Yes:	Claims	1-11
	No:	Claims	

2. Citations and explanations

   see separate sheet

Re Item V

Reasoned statement with regard to novelty, inventive step or industrial applicability; citations and explanations supporting such statement

1. The document GB-A-2 348 062, which is regarded as being the closest prior art to the subject-matter of independent method claims 1 and independent apparatus 7, discloses:

Claim 1: A method for improving the output signal accuracy of a transmitter with a forward branch for converting an input signal into a signal for transmission, the forward branch comprising an adaptation unit for applying a predistortion to the input signal and a power amplifier, and with a first feedback branch, the first feedback branch generating a feedback signal from the signal for transmission, said feedback signal being fed back to the adaptation unit, wherein, in said first feedback branch, the frequency of said signal for transmission is down-converted and wherein the down-converted signal is analogue-to-digital converted, and wherein the predistortion applied to the input signal is determined according to the feedback signal, the method comprising the steps of: measuring the output power of said signal for transmission in a second feedback branch; converting analogue output power measurements of the second feedback branch to digital values.

Claim 7: A transmitter with a forward branch for converting an input signal into a signal for transmission, the forward branch comprising an adaptation unit for applying a predistortion to the input signal and a power amplifier, and with a first feedback branch, the first feedback branch being adapted to generate a feedback signal from the signal for transmission by down-converting the frequency of said signal for transmission and converting the down-converted signal analogue-to-digital and being connected to the adaptation unit, wherein the adaptation unit is adapted to determine said predistortion according to the feedback signal, wherein the transmitter comprises a second feedback branch with a measurement unit for the output power of said signal for transmission, said second feedback branch being connected to the adaptation unit, and wherein the transmitter comprises means for converting analogue output power measurements of the second feedback branch to digital values.

1.1 The subject-matter of claim 1 differs from the method of document GB-A-2 348 062 in that the following additional steps are present:
processing said analog-to-digital converted signal values of said first feedback branch by an integrating method; comparing the processed analogue-to-digital converted signal values of

the first feedback branch with the digital values of the measurement; deriving a correction factor from said comparison and multiplying said analogue-to-digital converted values of the first feedback branch with said correction factor for adjusting the predistortion according to said measurement of the output power.
The subject-matter of independent claim 1 is therefore new (Article 33(2) PCT).

1.2 The subject-matter of claim 7 differs from the transmitter of document GB-A-2 348 062 in that the following additional apparatus features are present:
means for processing said analog-to-digital converted signal values of said first feedback branch by an integrating method; means for comparing the processed analogue-to-digital converted signal values of the first feedback branch with the digital values of the measurement; means for deriving a correction factor from said comparison, and means for multiplying said analogue-to-digital converted values of the first feedback branch with said correction factor for adjusting the predistortion according to said measurement of the output power.
The subject-matter of independent claim 7 is therefore new (Article 33(2) PCT).

The problem to be solved by the present invention may be regarded as the provision of a method for a transmitter and a transmitter having better accuracy and reliability of the transmitted output signal.

The solution to this problem proposed in claims 1 and 7 of the present application is considered as involving an inventive step (Article 33(3) PCT) because it uses the results of a comparison among the integrated version of the signal of said first feedback branch and the signal of said second feedback branch in order to control the predistortion of the signal which has to be transmitted.
It should be noted that the integration of a feedback signal is known in predistortion control methods (see Fig.3 and read the description, page 8, right-hand column, lines 22-38 of document US 2001/022532 A1) but no comparison among said integrated signal of a first feedback branch and the signal of the second feedback branch is disclosed in the documents which are cited in the search report.

2. Claim 5 is related to the computer program implementation of the method of claim 1, claims 2-4, 6 and 8-11 are dependent on claims 1, 5 and 7 respectively and as such also meet the requirements of the PCT with respect to novelty and inventive step.

down-converted to a low intermediate frequency (IF) or even to baseband and is generally also analog-to-digital converted. The downconversion requires one or even several mixing units, analog IF-filters and amplifiers. This analog equipment in communication system components such as radio base stations or mobile terminals is subject to high variations associated with environmental temperature and also aging and power supply variations. These effects lead to a continuously changing analog gain of the RF down-conversion unit. Due to the fact that the digital predistortion unit does not have precise information about the power level at the antenna reference point but relies only on the down-converted signal of the feedback branch coming from the power amplifier output, all gain uncertainties of the down-conversion feedback branch have a direct impact on the quality of the digitally predistorted signal. These gain uncertainties in the down-conversion feeback branch cause output power variations of the same magnitude.

Especially in CDMA systems like for example wideband CDMA, the output power of a radio base station or a mobile terminal has to be controlled accurately in order to avoid unnecessary interferences and therefore not to sacrifice cell and spectrum capacity. The solution so far has been to keep the gain uncertainty of the down-conversion chain in the feedback branch as low as possible. This approach, however, suffers from the disadvantage that the down-conversion components become very expensive, need a relevant amount of space in a hardware implementation and finally result in additional heat dissipation.

Several improvements have been proposed in order to improve the performance of an amplifier in a transmitter with a feedback loop. Application GB 2348062 describes an arrangement for linearizing the output of a transmitter.

Application US2002/193086 shows a transmitter with two parallel feedback branches, which provide feedback in different frequency bands.

Document US2002/158622 discloses a feedback amplifier, in which an additional measurement arrangement is provided to estimate the phase error of the feedback

loop. The measuring arrangement estimates the loop-phase error from the output of the amplifier on the basis of a test signal.

European application EP 598585 describes an automatic calibration procedure for an amplifier with signal feedback. The amplifier comprises a feedback branch with signal strength measurement, which is used for the calibration based on test signals.

However, none of the above documents provides a solution for improving the accuracy of the feedback signal in a simple way.

SUMMARY OF THE INVENTION

It is therefore an object of the present invention to overcome the above-mentioned problems and to provide a method for improving output signal accuracy of power amplifiers in a transmitter.

According to the invention, the method described in claim 1 is performed. Furthermore, the invention is embodied in a computer program product and a transmitter as described in claims 5 and 7, respectively. Advantageous embodiments are described in the further claims.

Claims:

1. A method for improving the output signal accuracy of a transmitter with a forward branch for converting an input signal into a signal for transmission, the forward branch comprising an adaptation unit (103) for applying a predistortion to the input signal and a power amplifier (106), and with a first feedback branch (110), the first feedback branch (110) generating a feedback signal from the signal for transmission, said feedback signal being fed back to the adaptation unit (103), wherein, in said first feedback branch (110), the frequency of said signal for transmission is down-converted and wherein the down-converted signal is analogue-to-digital converted, and wherein the predistortion applied to the input signal is determined according to the feedback signal,
the method comprising the steps of:
- measuring the output power of said signal for transmission in a second feedback branch (201)
- converting analogue output power measurements of the second feedback branch to digital values,
- processing said analog-to-digital converted signal values of said first feedback branch by an integrating method,
- comparing the processed analogue-to-digital converted signal values of the first feedback branch with the digital values of the measurement,
- deriving a correction factor from said comparison, and
- multiplying said analogue-to-digital converted values of the first feedback branch with said correction factor for adjusting the predistortion according to said measurement of the output power.

2. The method according to claim 1, wherein the adjusting according to said measurement is performed on the feedback signal.

3. The method according to claim 1 or 2, wherein said measurement of the output power is performed by an integrating method.

4. The method according to any preceding claim, wherein the same time constant is used for integrating the output power measurement of the second feedback branch and for integrating said analog-to-digital-converted signal values of the first feedback branch.

5. A computer program product comprising program code portions for performing the steps of any of claims 1 to 4 when the computer program product is run on a computing device.

6. The computer program product of claim 5, stored on a computer readable recording medium.

7. A transmitter with a forward branch for converting an input signal into a signal for transmission, the forward branch comprising an adaptation unit (103) for applying a predistortion to the input signal and a power amplifier (106), and with a first feedback branch (110), the first feedback branch (110) being adapted to generate a feedback signal from the signal for transmission by down-converting the frequency of said signal for transmission and converting the down-converted signal analogue-to-digital and being connected to the adaptation unit (103), wherein the adaptation unit (103) is adapted to determine said predistortion according to the feedback signal, wherein
- the transmitter comprises a second feedback (201) branch with a measurement unit (202) for the output power of said signal for transmission, said second feedback branch (201) being connected to the adaptation unit (103), and wherein the transmitter comprises
- means for converting analogue output power measurements of the second feedback branch to digital values,
- means for processing said analog-to-digital converted signal values of said first feedback branch by an integrating method,
- means for comparing the processed analogue-to-digital converted signal values of the first feedback branch with the digital values of the measurement,
- means for deriving a correction factor from said comparison, and

- means for multiplying said analogue-to-digital converted values of the first feedback branch with said correction factor
for adjusting the predistortion according to said measurement of the output power.

8. The transmitter according to claim 7, wherein said first feedback branch comprises a frequency converter (108) and an analog-to-digital converter (109).

9. The transmitter according to claim 7 or 8, wherein said measurement unit (202) is an integrating measurement unit.

10. The transmitter according to any of the claims 7 to 9, wherein said adaptation unit (103) is adapted to adjust the predistortion according to said measurement.

11. The transmitter according to any of the claims 7 to 10, wherein said adaptation unit (103) is a predistortion unit.